

## CLAIMS

1. An optical information recording/reproducing apparatus, comprising:
  - an optical recording medium for storing information with marks of a
  - 5 plurality of lengths;
  - light irradiation means for irradiating the optical recording medium with a light beam so as to form each mark;
  - light driving means for allowing the light irradiation means to emit light with desired light intensity;
  - 10 recording waveform control means for controlling a recording waveform in accordance with a length of a mark to be recorded;
  - recording output variation means for instructing the light driving means to perform test recording in a light intensity learning region on the optical recording medium with desired light intensity;
  - 15 modulation degree detection means for detecting a degree of modulation from an amplitude of a reproduced signal of a test-recorded mark;
  - waveform distortion detection means for detecting waveform distortion of the reproduced signal of the test-recorded mark;
  - first light intensity calculation means for calculating recording light
  - 20 intensity corresponding to an allowable upper limit degree of modulation for the optical recording medium based on the degree of modulation of the reproduced signal of each of the plural marks test-recorded with a plurality of light intensity values in the light intensity learning region and the allowable upper limit degree of modulation;
  - 25 second light intensity calculation means for calculating recording light intensity corresponding to an allowable waveform distortion amount for the optical recording medium based on the waveform distortion amount of the reproduced signal of each of the plural marks test-recorded with a plurality of light intensity values in the light intensity learning region and the allowable
  - 30 waveform distortion amount;

allowable light intensity range determination means for determining a light intensity range for recording information on the optical recording medium based on the recording light intensity corresponding to the allowable upper limit degree of modulation and the recording light intensity  
5 corresponding to the allowable waveform distortion amount; and

optimum light intensity determination means for determining optimum recording light intensity within the light intensity range determined by the light intensity range determination means.

10 2. The optical information recording/reproducing apparatus according to claim 1, wherein the recording waveform control means outputs a recording waveform having high first recording light intensity for recording a mark whose length is shorter than a first mark length, and outputs a recording waveform having the first recording light intensity for a front-end portion  
15 and a rear-end portion of the recording waveform and having second recording light intensity not higher than the first recording light intensity for an intermediate portion of the recording waveform for recording a mark whose length is not shorter than the first mark length.

20 3. The optical information recording/reproducing apparatus according to claim 2, wherein the recording output variation means sets the first recording light intensity and the second recording light intensity variably while maintaining a ratio between the first recording light intensity and the second recording light intensity at a constant value.

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4. The optical information recording/reproducing apparatus according to claim 3,

wherein the allowable light intensity range determination means compares the recording light intensity corresponding to the allowable upper  
30 limit degree of modulation with the recording light intensity corresponding to

the allowable waveform distortion amount, and

the allowable light intensity range determination means determines the recording light intensity range such that the recording light intensity corresponding to the allowable upper limit degree of modulation is an upper  
5 limit and the recording light intensity corresponding to the allowable waveform distortion amount is a lower limit when the recording light intensity corresponding to the allowable upper limit degree of modulation is not lower than the recording light intensity corresponding to the allowable waveform distortion amount, while

10 the allowable light intensity range determination means instructs the recording waveform control means to output a recording waveform having the first light intensity for a part of an intermediate portion of the recording waveform for a mark whose length is not shorter than a second mark length that is longer than the first mark length when the recording light intensity  
15 corresponding to the allowable upper limit degree of modulation is lower than the recording light intensity corresponding to the allowable waveform distortion amount.

5. The optical information recording/reproducing apparatus according to  
20 claim 3,

wherein the allowable light intensity range determination means compares the recording light intensity corresponding to the allowable upper limit degree of modulation with the recording light intensity corresponding to the allowable waveform distortion amount, and

25 the allowable light intensity range determination means determines the recording light intensity range such that the recording light intensity corresponding to the allowable upper limit degree of modulation is an upper limit and the recording light intensity corresponding to the allowable waveform distortion amount is a lower limit when the recording light  
30 intensity corresponding to the allowable upper limit degree of modulation is

not lower than the recording light intensity corresponding to the allowable waveform distortion amount, while

the allowable light intensity range determination means instructs the recording output variation means to change the ratio between the first recording light intensity and the second recording light intensity so as to increase the second recording light intensity when the recording light intensity corresponding to the allowable upper limit degree of modulation is lower than the recording light intensity corresponding to the allowable waveform distortion amount.

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6. An optical information recording/reproducing apparatus, comprising:

an optical recording medium for storing information with marks of a plurality of lengths;

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light irradiation means for irradiating the optical recording medium with a light beam so as to form each mark;

light driving means for allowing the light irradiation means to emit light with desired light intensity;

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recording waveform control means for outputting a recording waveform having high first recording light intensity when a mark to be recorded has a length shorter than a first mark length, and outputting a recording waveform having the first recording light intensity for a front-end portion and a rear-end portion of the recording waveform and having second recording light intensity not higher than the first recording light intensity for an intermediate portion of the recording waveform when a mark to be

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recorded has a length not shorter than the first mark length;

recording output variation means for setting the second recording light intensity variably while maintaining the first recording light intensity at a constant value, and instructing the light driving means to perform test recording in a light intensity learning region on the optical recording

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medium;

modulation degree detection means for detecting a degree of modulation from an amplitude of a reproduced signal of a test-recorded mark;

waveform distortion detection means for detecting waveform distortion of a reproduced signal of the test-recorded mark;

5 first light intensity calculation means for calculating recording light intensity corresponding to an allowable upper limit degree of modulation for the optical recording medium based on the degree of modulation of the reproduced signal of each of the plural marks test-recorded with the plurality of second recording light intensity values in the light intensity learning region  
10 and the allowable upper limit degree of modulation;

second light intensity calculation means for calculating recording light intensity corresponding to a target waveform distortion amount for the optical recording medium based on the waveform distortion amount of the reproduced signal of each of the plural marks test-recorded with the plurality  
15 of second recording light intensity values in the light intensity learning region and the target waveform distortion amount;

light intensity ratio determination means for determining a ratio of the recording light intensity values in the respective portions of the recording waveform for recording information on the optical recording medium based  
20 on the recording light intensity corresponding to the allowable upper limit degree of modulation and the recording light intensity corresponding to the target waveform distortion amount; and

optimum light intensity determination means for determining optimum recording light intensity at the recording light intensity ratio  
25 determined by the light intensity ratio determination means.

7. The optical information recording/reproducing apparatus according to claim 6,

wherein the light intensity ratio determination means compares the  
30 recording light intensity corresponding to the allowable upper limit degree of

modulation with the recording light intensity corresponding to the target waveform distortion amount, and

the light intensity ratio determination means determines the ratio of the recording light intensity values using the recording light intensity  
 5 corresponding to the target waveform distortion amount when the recording light intensity corresponding to the allowable upper limit degree of modulation is not lower than the recording light intensity corresponding to the target waveform distortion amount, while

the light intensity ratio determination means instructs the recording  
 10 waveform control means to output a recording waveform having the first recording light intensity for a part of an intermediate portion of the recording waveform for a mark whose length is not shorter than a second mark length that is longer than the first mark length when the recording light intensity corresponding to the allowable upper limit degree of modulation is lower than  
 15 the recording light intensity corresponding to the target waveform distortion amount.

8. A method for learning recording light intensity of an optical information recording/reproducing apparatus for recording information by irradiating an  
 20 optical recording medium having a light intensity learning region with a light beam so as to form marks of a plurality of lengths, wherein a mark of predetermined mark length or longer is formed with the light beam in conformity with a recording waveform in which a front-end portion and a rear-end portion of the recording waveform are set to have high first  
 25 recording light intensity and an intermediate portion of the recording waveform is set to have second recording light intensity not higher than the first recording light intensity, whereby the mark is formed, the method comprising:

(a) changing each of the first recording light intensity and the second  
 30 recording light intensity step by step by a predetermined amount while



maintaining a ratio between the first recording light intensity and the second recording light intensity at a constant value, and recording a light intensity learning pattern composed of a plurality of marks including an approximately longest mark in the light intensity learning region;

5 (b) detecting a degree of modulation of a reproduced signal of each of the plural marks in the recorded light intensity learning pattern;

(c) detecting a waveform distortion amount of a reproduced signal of the approximately longest mark in the recorded light intensity learning pattern;

10 (d) obtaining recording light intensity corresponding to an allowable upper limit degree of modulation based on the detected degree of modulation and the allowable upper limit degree of modulation;

(e) obtaining recording light intensity corresponding to an allowable distortion amount based on the detected waveform distortion amount and the  
15 allowable waveform distortion amount;

(f) comparing the recording light intensity corresponding to the allowable upper limit degree of modulation with the recording light intensity corresponding to the allowable waveform distortion amount; and

(g) setting recording light intensity for recording information within a  
20 range between an upper limit and a lower limit, the upper limit being the recording light intensity corresponding to the allowable upper limit degree of modulation and the lower limit being the recording light intensity corresponding to the allowable waveform distortion amount, when the recording light intensity corresponding to the allowable upper limit degree of  
25 modulation is not lower than the recording light intensity corresponding to the allowable waveform distortion amount.

9. The method for learning recording light intensity according to claim 8, further comprising (h) setting a part of the intermediate portion of the  
30 recording waveform to have the first recording light intensity when the

recording light intensity corresponding to the allowable upper limit degree of modulation is lower than the recording light intensity corresponding to the allowable waveform distortion amount and the intermediate portion is set to have the second recording light intensity.

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10. The method for learning recording light intensity according to claim 9, further comprising (i) extending a time period of the part of the intermediate portion of the recording waveform when the recording light intensity corresponding to the allowable upper limit degree of modulation is lower than  
10 the recording light intensity corresponding to the allowable waveform distortion amount and the part of the intermediate portion is set to have the first recording light intensity.

11. A method for learning recording light intensity of an optical information  
15 recording/reproducing apparatus for recording information by irradiating an optical recording medium having a light intensity learning region with a light beam so as to form marks of a plurality of lengths, wherein a mark of predetermined mark length or longer is formed with the light beam in conformity with a recording waveform in which a front-end portion and a  
20 rear-end portion of the recording waveform are set to have high first recording light intensity and an intermediate portion of the recording waveform is set to have second recording light intensity not higher than the first recording light intensity, whereby the mark is formed, the method comprising:

25 (a) changing the second recording light intensity step by step by a predetermined amount while maintaining the first recording light intensity at a constant value, and recording a light intensity learning pattern composed of a plurality of marks including an approximately longest mark in the light intensity learning region;

30 (b) detecting a degree of modulation of a reproduced signal of each of



the plural marks in the recorded light intensity learning pattern;

(c) detecting a waveform distortion amount of a reproduced signal of the approximately longest mark in the recorded light intensity learning pattern;

5 (d) obtaining recording light intensity corresponding to an allowable upper limit degree of modulation based on the detected degree of modulation and the allowable upper limit degree of modulation;

(e) obtaining recording light intensity corresponding to a target waveform distortion amount based on the detected waveform distortion  
10 amount and the target waveform distortion amount;

(f) comparing the recording light intensity corresponding to the allowable upper limit degree of modulation with the recording light intensity corresponding to the target waveform distortion amount; and

(g) setting the recording light intensity corresponding to the target  
15 waveform distortion amount as the second recording light intensity, and determining a ratio between the first recording light intensity and the set second recording light intensity as an optimum light intensity ratio when the recording light intensity corresponding to the allowable upper limit degree of modulation is not lower than the recording light intensity corresponding to  
20 the target waveform distortion amount.

12. The method for learning recording light intensity according to claim 10, further comprising (h) setting a part of the intermediate portion of the recording waveform to have the first recording light intensity when the  
25 recording light intensity corresponding to the allowable upper limit degree of modulation is lower than the recording light intensity corresponding to the target waveform distortion amount and the intermediate portion is set to have the second recording light intensity.

30 13. The method for learning recording light intensity according to claim 12,

further comprising (i) extending a time period of the part of the intermediate portion of the recording waveform when the recording light intensity corresponding to the allowable upper limit degree of modulation is lower than the recording light intensity corresponding to the target waveform distortion amount and the part of the intermediate portion is set to have the first recording light intensity.